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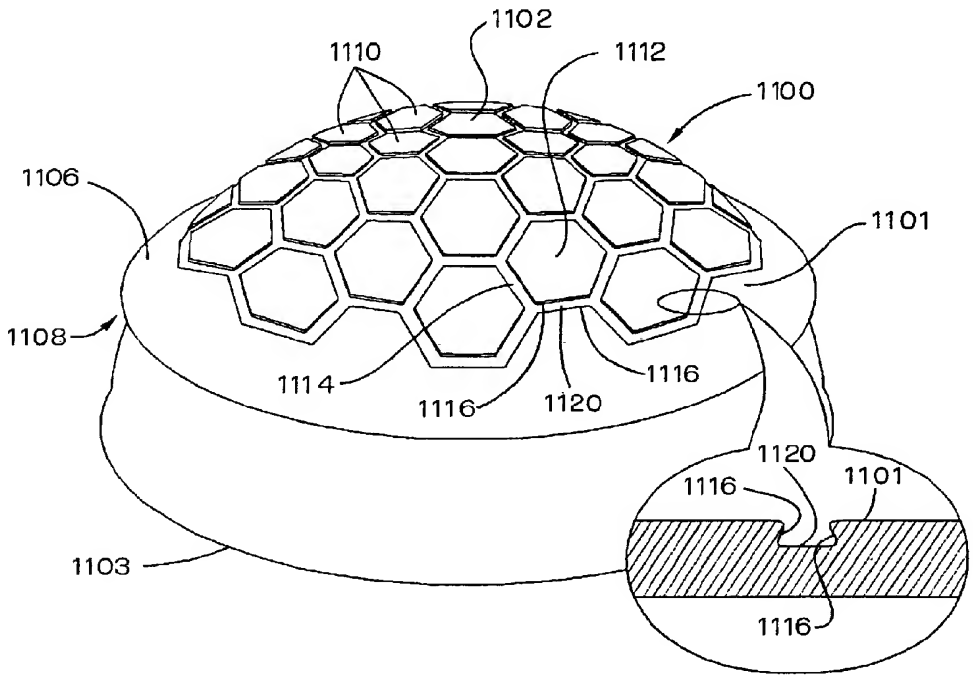

(57) Abstract: An implantable artificial joint prosthesis including at least one joint defining element defining a bone-engaging surface, the bone-engaging surface including an anchoring mechanism operative for enhancing anchoring and adhesion of the joint defining element to the bone and thus improving the stability and longevity of the prosthesis.

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JOINT PROSTHESES

FIELD OF THE INVENTION

The present invention relates generally to joint implants and methods relating thereto.

REFERENCE TO RELATED APPLICATIONS

This application is partially based upon and claims priority from U.S. Provisional Patent Application Serial No. 60/351,755 filed January 24, 2002 and entitled "CONFIGURATION–PATTERN, TEXTURE, REINFORCEMENT AND COATING ON PROSTHESIS SURFACE ENGAGING BONE; AND SURFACE TREATMENT OF ARTICULATING SURFACE" and U.S. Provisional Patent Application Serial No. 60/383,483 filed May 23, 2002 and entitled "JOINT IMPLANTS SYSTEM AND METHODOLOGY AND IMPLANTS AND TOOLS USEFUL THEREWITH".

BACKGROUND OF THE INVENTION

The following patents are believed to be relevant to the subject matter of this application:

U.S. patents 5,201,881; 5,011,497; 4,279,041; 5,080,675; 4,650,491; 3,938,198; 4,292,695; 4,624,674; 2,765,787; 4.735,625; 5,370,699; 5,641,323; 5,323,765; 5,658,345; 3,875,594; 3,938,198; 4,292,695; 4,344,193; 4,570,270; 4,650,491; 4,279,041; 4,661,112; 4,662,889; 4,664,668; 4,715,859; 4,795,470; 4,795,474; 4,808,186; 4,813,962; 4,822,365; 4,888,020; 4,904,269; 4,908,035; 4,919,674; 4,919,678; 4,936,856; 4,938,771; 4,938,773; 4,950,298; 4,955,912; 4,955,919; 4,963,153; 4,963,154; 4,997,447; 5,002,581; 5,019,107; 5,041,140; 5,049,393; 5,080,677; 5,108,446; 5,108,451; 5,116,374; 5,133,763; 5,146,933; 5,147,406; 5,151,521; 5,156,631; 5,171,276; 5,181,925; 5,197,987; 5,197,989;

5,201,881; 5,201,882; 5,217,498; 5,217,499; 5,222,985; 5,282,868; 5,290,314; 5,314,478; 5,314,494; 5,316,550; 5,326,376; 5,330,534; 5,314,493; 5,336,268; 5,344,459; 5,358,525; 5,370,699; 5,376,064; 5,376,125; 5,387,244; 5,389,107; 5,405,403; 5,405,411; 5,415,662; 5,425,779; 5,448,489; 5,458,643; 5,458,651; 5,489,311; 5,491,882; 5,507,814; 5,507,818; 5,507,820; 5,507,823; 5,507,830; 5,507,833; 5,507,836; 5,514,182; 5,514,184; 5,522,904; 5,507,835; 5,246,461; 5,364,839; 5,376,120; 5,393,739; 5,480,449; 5,510,418; 5,522,894; 4,892,551; 5,660,225; 4,089,071; 5,281,226; 5,443,383; 5,480,437; 5,032,134; 4,997,444; 5,002,579; 5,443,512; 5,133,762; 5,080,678; 5,944,759; 5,944,758; 5,944,757; 5,944,756; 5,938,702; 5,935,174; 5,935,175; 5,935,173; 5,935,172; 5,935,171; 5,931,871; 5,931,870; 5,928,289; 5,928,288; 5,928,287; 5,928,286; 5,928,285; 5,919,236; 5,916,270; 5,916,269; 5,916,268; 5,913,858; 5,911,759; 5,911,758; 5,910,172; 5,910,171; 5,906,644; 5,906,643; 5,906,210; 5,904,720; 5,904,688; 5,902,340; 5,882,206; 5,888,204; 5,879,407; 5,879,405; 5,879,404; 5,879,402; 5,879,401; 5,879,398; 5,879,397; 5,879,396; 5,879,395; 5,879,393; 5,879,392; 5,879,390; 5,879,387; 5,871,548; 5,871,547; 5,824,108; 5,824,107; 5,824,103; 5,824,102; 5,824,101; 5,824,098; 5,800,560; 5,800,558; 5,800,557; 5,800,555; 5,800,554; 5,800,553; 5,788,704; 5,782,928; 5,782,925; 5,776,202; 5,766,260; 5,766,257; 5,755,811; 5,755,810; 5,755,804; 5,755,801; 5,755,799; 5,743,918; 5,910,172; 5,211,666; 5,507,832; 4,433,440; 5,397,359; 5,507,834; 5,314,492; 5,405,394; 5,316,550; 5,314,494; 5,413,610; 5,507,835; 5,373,621; 5,433,750; 3,879,767; 5,376,123; 5,480,437; 3,576,133; 5,376,126; 5,496,375; 3,600,718; 5,108,449; 5,507,817; 5,181,929 and 5,507,829.

Foreign patents DE 2,247,721; EP 0,308,081; GB 2,126,096; GB 2,069,338; EP 0,190,446; EP 0,066,092 and EP 0,253,941.

SUMMARY OF THE INVENTION

The present invention seeks to provide improved joint implants and methods relating to joint implantation.

There is thus provided in accordance with a preferred embodiment of the

present invention an implantable artificial joint prosthesis including at least one joint defining element defining a bone-engaging surface, the bone-engaging surface including an anchoring mechanism operative for enhancing anchoring and adhesion of the joint defining element to the bone and thus improving the stability and longevity of the prosthesis.

In accordance with another preferred embodiment of the present invention the at least one joint defining element is formed of a material having mechanical properties which are characterized by a non linear stress strain relationship.

In accordance with yet another preferred embodiment of the present invention the at least one joint defining element defines a generally hemispherical convex bone-engaging surface. Preferably, the at least one bone engagement surface has formed thereon a generally annular outwardly extending protrusion.

Alternatively, the at least one joint defining element defines a generally hemispherical concave bone-engaging surface. Preferably, the at least one bone engagement surface has formed thereon a generally annular inwardly extending protrusion.

In accordance with another preferred embodiment of the present invention the protrusion defines a generally annular undercut.

In accordance with still another preferred embodiment of the present invention the at least one bone-engaging surface is arranged for snap fit engagement with a bone. Additionally or alternatively, the at least one bone-engaging surface is arranged for press fit engagement with a bone.

In accordance with a preferred embodiment of the present invention, the at least one bone-engaging surface is configured with a hexagonal configuration pattern. Preferably, the hexagonal configuration pattern is defined by a plurality of protruding hexagonal contact surface portions, each surrounded by a peripheral channel. Alternatively, the hexagonal configuration pattern is defined by a plurality of recessed hexagonal contact surface portions, each surrounded by a peripheral channel. Preferably, the channels are each defined by wall surfaces and a bottom surface. Additionally or alternatively, the channels are defined to provide an undercut engagement portion.

In accordance with yet another preferred embodiment of the present

invention the undercut engagement portion includes a relatively wider cross sectional dimension near the bottom surface and a relatively narrower cross sectional dimension away from the bottom surface.

In accordance with another preferred embodiment, the at least one bone-engaging surface is configured with a spiral configuration pattern. Preferably, the spiral configuration pattern is defined by spiral recess. Additionally, the spiral recess is defined by wall surfaces and a bottom surface. Additionally or alternatively, the spiral recess is defined to provide an undercut engagement portion. Preferably, the undercut engagement portion includes a relatively wider cross sectional dimension near the bottom surface and a relatively narrower cross sectional dimension away from the bottom surface.

In accordance with still another preferred embodiment of the present invention the at least one bone-engaging surface is configured with a pattern defined by a plurality of multidirectional generally radially extending elongate recesses. Preferably, the recesses are defined by wall surfaces and a bottom surface. Additionally or alternatively, the recesses are defined to provide an undercut engagement portion. Preferably, the undercut engagement portion includes a relatively wider cross sectional dimension near the bottom surface and a relatively narrower cross sectional dimension away from the bottom surface.

In accordance with another preferred embodiment of the present invention the at least one bone-engaging surface is configured with a geometric configuration pattern.

In accordance with yet another preferred embodiment of the present invention the at least one bone-engaging surface is configured with a fractal configuration pattern.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

Figs. 1, 2, 3 and 4 are pictorial illustrations of an implantable artificial

socket constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 5A is a simplified exploded view illustration of an implantable artificial tibial socket assembly constructed and operative in accordance with a preferred embodiment of the present invention in association with a suitably machined tibia;

Fig. 5B is a simplified illustration a tibia, suitably machined to receive the implantable artificial tibial socket assembly of Fig. 5A;

Fig. 6A is a simplified exploded view illustration of an implantable artificial femoral surface element assembly constructed and operative in accordance with a preferred embodiment of the present invention in association with a suitably machined femur; and

Fig. 6B is a simplified illustration of a femur suitably machined to receive the implantable artificial femoral surface element assembly of Fig. 6A.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Reference is now made to Fig. 1, which is a pictorial illustration of an implantable artificial socket constructed and operative in accordance with a preferred embodiment of the present invention and which is particularly suitable for use in a hip joint. The embodiment of Fig. 1 is particularly directed to providing an anchoring mechanism on a bone-engaging surface of the artificial socket for enhancing the anchoring and adhesion of the socket to the bone and thus improving the stability and longevity of the prosthesis.

As seen in Fig. 1, an implantable artificial socket, designated by reference numeral 1100, is formed preferably by injection molding of a pliable material such as an elastomer, preferably polyurethane, having mechanical properties which are characterized by a non linear stress strain relationship.

Preferably, implantable artificial socket 1100 is of generally uniform thickness and defines a generally hemispherical convex bone engagement surface 1101 which preferably has formed thereon, at any suitable location between its apex 1102 and its rim 1103, a generally annular outwardly extending protrusion 1106, preferably defining a generally annular undercut 1108. Alternatively, the protrusion 1106 may be

any other suitable annular or non-annular, continuous or discontinuous, generally peripheral, protrusion. The protrusion 1106 is preferably arranged for snap-fit engagement with a corresponding groove formed by reaming of a bone.

In accordance with another preferred embodiment of the present invention, the relationship between the form and the dimensions of implantable artificial socket 1100 and the protrusion 1106 are, with respect to the form and the dimensions of the corresponding reamed bone, preferably arranged for press-fit and snap-fit engagement with the bone. The press-fit feature is typically provided by making the outer dimensions of socket 1100 slightly larger than the corresponding dimensions of the machined bone surface onto which the socket fits.

The convex bone engagement surface 1101 is preferably configured with a hexagonal configuration pattern 1110, preferably defined by a plurality of protruding hexagonal contact surface portions 1112, each surrounded by a peripheral channel 1114. Channels 1114 are defined by wall surfaces 1116 and a bottom surface 1120. In accordance with a preferred embodiment of the present invention, channels 1114 are configured with wall surfaces 1116 being inclined outwardly toward the bottom surface 1120, creating an undercut configuration having a relatively wider cross sectional dimension near the bottom surface and a relatively narrower cross sectional dimension away from the bottom surface.

It is a particular feature of the embodiment of Fig. 1 that when the artificial joint equipped with implantable artificial socket 1100 experiences forces and/or impacts, such as those having a cyclic nature resulting from walking or running, the resulting stresses and strains exerted within the bone in proximity to the bone engagement surface 1101 induce growth of new bone cells, which, gradually, over time migrate into the channels 1114. The new bone cells typically press on other cells, creating remodeling of the bone in engagement with bone engagement surface 1101, causing the bone to migrate into the channels 1114 gradually, over time, and thus create an undercut locking engagement with the socket 1100.

Reference is now made to Fig. 2, which is a pictorial illustration of an implantable artificial socket constructed and operative in accordance with a preferred embodiment of the present invention and which is particularly suitable for use in a hip joint. The embodiment of Fig. 2 is also particularly directed to providing an anchoring

mechanism on a bone-engaging surface of the artificial socket for enhancing the anchoring and adhesion of the socket to the bone and thus improving the stability and longevity of the prosthesis.

As seen in Fig. 2, an implantable artificial socket, designated by reference numeral 1200, is formed preferably by injection molding of a pliable material such as an elastomer, preferably polyurethane, having mechanical properties which are characterized by a non linear stress strain relationship.

Preferably, implantable artificial socket 1200 is of generally uniform thickness and defines a generally hemispherical convex bone engagement surface 1201 which preferably has formed thereon, at any suitable location between its apex 1202 and its rim 1203, a generally annular outwardly extending protrusion 1206, preferably defining a generally annular undercut 1208. Alternatively, the protrusion 1206 may be any other suitable annular or non-annular, continuous or discontinuous, generally peripheral, protrusion. The protrusion 1206 is preferably arranged for snap-fit engagement with a corresponding groove formed by reaming of a bone.

In accordance with another preferred embodiment of the present invention, the relationship between the form and the dimensions of implantable artificial socket 1200 and the protrusion 1206 are, with respect to the form and the dimensions of the corresponding reamed bone, preferably arranged for press-fit and snap-fit engagement with the bone. The press-fit feature is typically provided by making the outer dimensions of socket 1200 slightly larger than the corresponding dimensions of the machined bone surface onto which the socket fits.

The convex bone engagement surface 1201 is preferably configured with a hexagonal configuration pattern 1210 preferably defined by a plurality of recessed hexagonal contact surface portions 1212, each surrounded by a peripheral ridge 1214. Ridges 1214 are defined by wall surfaces 1216 and a top surface 1220. In accordance with a preferred embodiment of the present invention, ridges 1214 are configured with wall surfaces 1216 being inclined outwardly toward the top surface 1220, creating an undercut configuration at said recessed hexagonal contact surface portions 1212 having a relatively wider cross sectional dimension near surface portions 1212 and a relatively narrower cross sectional dimension away from the surface portions 1212.

It is a particular feature of the embodiment of Fig. 2 that when the

artificial joint equipped with implantable artificial socket 1200 experiences forces and/or impacts, such as those having a cyclic nature resulting from walking or running, the resulting stresses and strains exerted within the bone in proximity to the bone engagement surface 1201 induce growth of new bone cells, which, gradually, over time, migrate into the regions above surface portions 1212. The new bone cells typically press on other cells, creating remodeling of the bone in engagement with bone engagement surface 1201, causing the bone to migrate into the regions above surface portions 1212 gradually, over time, and thus create an undercut locking engagement with the socket 1200.

Reference is now made to Fig. 3, which is a pictorial illustration of an implantable artificial socket constructed and operative in accordance with a preferred embodiment of the present invention and which is particularly suitable for use in a hip joint.

As seen in Fig. 3, an implantable artificial socket, designated by reference numeral 2100, is formed preferably by injection molding of a pliable material such as an elastomer, preferably polyurethane, having mechanical properties which are characterized by a non linear stress strain relationship.

Preferably, implantable artificial socket 2100 is of generally uniform thickness and defines a generally hemispherical convex bone engagement surface 2101 which preferably has formed thereon, at any suitable location between its apex 2102 and its rim 2103, a generally annular outwardly extending protrusion 2106, preferably defining a generally annular undercut 2108. Alternatively, the protrusion 2106 may be any other suitable annular or non-annular, continuous or discontinuous, generally peripheral, protrusion. The protrusion 2106 is preferably arranged for snap-fit engagement with a corresponding groove formed by reaming of a bone.

In accordance with another preferred embodiment of the present invention, the relationship between the form and the dimensions of implantable artificial socket 2100 and the protrusion 2106 are, with respect to the form and the dimensions of the corresponding reamed bone, preferably arranged for press-fit and snap-fit engagement with the bone. The press-fit feature is typically provided by making the outer dimensions of socket 2100 slightly larger than the corresponding dimensions of the machined bone surface onto which the socket fits.

The convex bone engagement surface 2101 is preferably configured with a spiral configuration pattern 2110 preferably defined by a recess 2112 configured in a spiral. Spiral recess 2112 is defined by wall surfaces 2116 and a bottom surface 2120. In accordance with a preferred embodiment of the present invention, spiral recess 2112 is configured with wall surfaces 2116 being inclined outwardly toward the bottom surface 2120, creating an undercut configuration having a relatively wider cross sectional dimension near the bottom surface and a relatively narrower cross sectional dimension away from the bottom surface. It is appreciated that, even though the illustrated embodiment shows a circular spiral configuration pattern 2110, any suitable spiral configuration pattern, such as an elliptic or non-symmetric spiral pattern, or any combination thereof, may be provided.

It is a particular feature of the embodiment of Fig. 3 that when the artificial joint equipped with implantable artificial socket 2100 experiences forces and/or impacts, such as those having a cyclic nature resulting from walking or running, the resulting stresses and strains exerted within the bone in proximity to the bone engagement surface 2101 induce growth of new bone cells, which, gradually, over time, migrate into the spiral recess 2112. The new bone cells typically press on other cells, creating remodeling of the bone in engagement with bone engagement surface 2101, causing the bone to migrate into the spiral recess 2102 gradually over time and thus create an undercut locking engagement with the socket 2100.

Reference is now made to Fig. 4, which is a pictorial illustration of an implantable artificial socket constructed and operative in accordance with a preferred embodiment of the present invention and which is particularly suitable for use in a hip joint.

As seen in Fig. 4, an implantable artificial socket, designated by reference numeral 2200, is formed preferably by injection molding of a pliable material such as an elastomer, preferably polyurethane, having mechanical properties which are characterized by a non linear stress strain relationship.

Preferably, implantable artificial socket 2200 is of generally uniform thickness and defines a generally hemispherical convex bone engagement surface 2201 which preferably has formed thereon, at any suitable location between its apex 2202 and its rim 2203, a generally annular outwardly extending protrusion 2206, preferably

defining a generally annular undercut 2208. Alternatively, the protrusion 2206 may be any other suitable annular or non-annular, continuous or discontinuous, generally peripheral, protrusion. The protrusion 2206 is preferably arranged for snap-fit engagement with a corresponding groove formed by reaming of a bone.

In accordance with another preferred embodiment of the present invention the relationship between the form and the dimensions of implantable artificial socket 2200 and the protrusion 2206 are, with respect to the form and the dimensions of the corresponding reamed bone, preferably arranged for press-fit and snap-fit engagement with the bone. The press-fit feature is typically provided by making the outer dimensions of socket 2200 slightly larger than the corresponding dimensions of the machined bone surface onto which the socket fits.

The convex bone engagement surface 2201 is preferably configured with a pattern 2210 preferably defined by a plurality of multidirectional generally radially extending elongate recesses 2214. Recesses 2214 are defined by wall surfaces 2216 and a bottom surface 2220. In accordance with a preferred embodiment of the present invention, recesses 2214 are configured with wall surfaces 2216 being inclined outwardly toward the bottom surface 2220, creating an undercut configuration having a relatively wider cross sectional dimension near the bottom surface and a relatively narrower cross sectional dimension away from the bottom surface.

It is a particular feature of the embodiment of Fig. 4 that when the artificial joint equipped with implantable artificial socket 2200 experiences forces and/or impacts, such as those having a cyclic nature resulting from walking or running, the resulting stresses and strains exerted within the bone in proximity to the bone engagement surface 2201 induce growth of new bone cells, which, gradually, over time, migrate into the recesses 2214. The new bone cells typically press on other cells, creating remodeling of the bone in engagement with bone engagement surface 2201, causing the bone to migrate into the channels 2214 gradually, over time, and thus create an undercut locking engagement with the socket 2200.

It is appreciated that the hexagonal configuration pattern 1110 of Fig. 1 and the hexagonal configuration pattern 1210 of Fig. 2 are approximately obverse versions of the same pattern. It is appreciated that similar obverse versions of the configuration patterns of Figs. 3 and 4 may also be provided. It is further appreciated

that the illustrated patterns are intended as examples only, and any suitable configuration pattern, such as geometric or fractal patterns, may also be provided.

It is further appreciated that even though the illustrated embodiments comprise continuous configuration patterns, prostheses comprising any suitable combination of continuous or discontinuous configuration patterns, covering all or selected portions of the bone contact surface, may also be provided.

Reference is now made to Fig. 5A, which is a simplified exploded view illustration of an implantable artificial tibial socket assembly constructed and operative in accordance with a preferred embodiment of the present invention in association with a suitably machined tibia and to Fig. 5B, which is a simplified illustration a tibia, suitably machined to receive the implantable artificial tibial socket assembly of Fig. 5A.

As seen in Figs. 5A and 5B, an implantable artificial tibial socket assembly, designated by reference numeral 3900, is formed preferably by injection molding of a pliable material such as an elastomer, preferably polyurethane, having mechanical properties which are characterized by a non linear stress strain relationship.

Preferably, implantable artificial socket assembly 3900 defines a concave articulation surface 3902, which is defined on an articulation portion 3903, and a bone engagement surface 3904, which is defined on a bone engagement portion 3905. Bone engagement surface 3904 preferably has formed thereon multiple protrusions. In the illustrated embodiment, there are provided an inner protrusion 3906 and an outer peripheral protrusion 3908, defining respective undercuts 3910 and 3912. Alternatively, protrusions 3906 and 3908 may be any other suitable open or closed protrusions. Protrusions 3906 and 3908 are preferably arranged for snap-fit engagement with corresponding grooves 3914 and 3916 provided by machining of the tibia.

In accordance with a preferred embodiment of the present invention, bone engagement surface 3904 has formed thereon a pattern 3917 defined by a plurality of multidirectional elongate recesses 3918 similar to the pattern 2210 shown in Fig. 4. Alternatively, pattern 3917 may be a hexagonal configuration pattern, similar to pattern 1110 of Fig. 1 or 1210 of Fig. 2, or a spiral configuration pattern similar to pattern 2110 of Fig. 3. Additionally, as described hereinabove, obverse patterns of these patterns or any other suitable configuration pattern may also be provided.

Recesses 3918 are configured with wall surfaces 3919 and a bottom

surface 3920. In accordance with a preferred embodiment of the present invention recesses 3918 are configured to have wall surfaces 3919 inclined outwardly toward bottom surface 3920, creating an undercut configuration having a relatively wider cross sectional dimension near the bottom surface and a relatively narrower cross sectional dimension away from the bottom surface.

Articulation portion 3903 is formed with a highly resilient hollow peripheral rim 3921 arranged for snap-fit engagement with a corresponding peripheral socket 3922 formed in a surface of bone engagement portion 3905, opposite to bone engagement surface 3904 thereof. Articulation portion 3903 also is formed with a support protrusion 3923, defining an undercut 3924 and arranged for resilient snap-fit locking engagement with a corresponding groove 3926 formed in bone engagement portion 3905.

In accordance with a preferred embodiment of the present invention, articulation portion 3903 has formed in articulation surface 3902 a plurality of thoroughgoing apertures 3928 and side openings 3930, which allow synovial fluid to pass therethrough for lubrication of the articulation surface 3902.

It is a particular feature of the embodiment of Fig. 5A that when the artificial joint equipped with implantable artificial tibial socket assembly 3900 experiences forces and/or impacts, such as those having a cyclic nature resulting from walking or running, the resulting stresses and strains exerted within the bone in proximity to the bone engagement surface 3904 induce growth of new bone cells, which, gradually, over time, migrate into the recesses 3918. The new bone cells typically press on other cells, creating remodeling of the bone in engagement with bone engagement surface 3904, causing the bone to migrate into the recesses 3918 gradually, over time, and thus create an undercut locking engagement with the socket assembly 3900.

Reference is now made to Fig. 6A, which is a simplified exploded view illustration of an implantable artificial femoral surface element assembly constructed and operative in accordance with a preferred embodiment of the present invention in association with a suitably machined femur and to Fig. 6B, which is a simplified illustration of a femur, suitably machined to receive the implantable artificial femoral surface element assembly of Fig. 6A.

As seen in Figs. 6A and 6B, an implantable artificial femoral surface element assembly, designated by reference numeral 4000, is formed preferably by injection molding of a pliable material such as an elastomer, preferably polyurethane, having mechanical properties which are characterized by a non linear stress strain relationship.

Preferably, implantable artificial socket assembly 4000 defines a convex articulation surface 4002, which is defined on an articulation portion 4003, and a bone engagement surface 4004, which is defined on a bone engagement portion 4005. Bone engagement surface 4004 preferably has formed thereon multiple protrusions.

In the illustrated embodiment, there are provided an inner protrusion 4006 and an outer peripheral protrusion 4008, defining respective undercuts 4010 and 4012. Alternatively, protrusions 4006 and 4008 may be any other suitable open or closed protrusions. Protrusions 4006 and 4008 are preferably arranged for snap-fit engagement with corresponding grooves 4014 and 4016 provided by machining of a femur medial condyle.

In accordance with a preferred embodiment of the present invention, bone engagement surface 4004 has formed thereon a pattern 4017 defined by a plurality of multidirectional elongate recesses 4018 similar to the pattern 2210 shown in Fig. 4. Alternatively, pattern 4017 may be a hexagonal configuration pattern, similar to pattern 1110 of Fig. 1 or 1210 of Fig. 2, or a spiral configuration pattern similar to pattern 2110 of Fig. 3. Additionally, as described hereinabove, obverse patterns of these patterns or any other suitable configuration pattern may also be provided.

Recesses 4018 are configured with wall surfaces 4019 and a bottom surface 4020. In accordance with a preferred embodiment of the present invention recesses 4018 are configured to have wall surfaces 4019 inclined outwardly toward bottom surface 4020, creating an undercut configuration having a relatively wider cross sectional dimension near the bottom surface and a relatively narrower cross sectional dimension away from the bottom surface.

Articulation portion 4003 is formed with a highly resilient hollow peripheral rim 4021 arranged for snap-fit engagement with a corresponding peripheral socket 4022 formed in a surface of bone engagement portion 4005, opposite to bone engagement surface 4004 thereof. Articulation portion 4003 also is formed with a

support protrusion 4023, defining an undercut 4024, and arranged for resilient snap-fit locking engagement with a corresponding groove 4026 formed in bone engagement portion 4005.

In accordance with a preferred embodiment of the present invention, articulation portion 4003 has formed in articulation surface 4002 a plurality of thoroughgoing apertures 4028 and side openings 4030, which allow synovial fluid to pass therethrough for lubrication of the articulation surface 4002.

It is a particular feature of the embodiment of Fig. 6 that when the artificial joint equipped with implantable artificial femoral surface element assembly 4000 experiences forces and/or impacts, such as those having a cyclic nature resulting from walking or running, the resulting stresses and strains exerted within the bone in proximity to the bone engagement surface 4004 induce growth of new bone cells which gradually over time migrate into the recesses 4018. The new bone cells typically press on other cells, creating remodeling of the bone in engagement with bone engagement surface 4004, causing the bone to migrate into the recesses 4018 gradually over time and thus to create an undercut locking engagement with the socket assembly 4000.

It is appreciated that even though the illustrated embodiments hereinabove show specific prosthetic devices, the provision of configuration patterns described herein may also be applied to any prosthesis that includes a bone engagement surface.

It is a particular feature of preferred embodiments of the prostheses described hereinabove that the combination of their configuration with the mechanical properties of the pliable material from which they are formed promotes bone growth and bone remodeling, enhancing anchoring and adhesion of the prostheses to the bone. The mechanical properties of the pliable material are characterized by a non-linear stress strain relationship, such that when one region of the prosthesis is subject to loading, the prosthesis deforms in one or more regions, including regions not directly adjacent to the region subject to the loading. These deformations are associated with the fluid-like quality of the pliable material and are not found in rigid materials. The loading and the deformations within the prosthesis cause pressure exerted by the prosthesis onto the adjacent bone to be distributed in a manner similar to hydrostatic pressure generated by pressurized fluid within a container.

This results in the creation of strain fields in the bone adjacent to the prosthesis with strain magnitudes comparable to those found in bones of a physically active person. It is this strain field, which is created in substantial portions of the bone, that activates bone growth and bone remodeling simulating natural bone growth and remodeling.

The bone remodeling process, associated with preferred embodiments of the prostheses of the present invention, may be a continuous process throughout the life of the prostheses. As described hereinabove, the migration of bone cells into the channels or recesses proceeds gradually over time. As new bone cells fill in the voids defined between the recessed area of the prosthesis and the bone surface, new areas of contact are created between bone and the walls of the recessed area. These new contact areas are operative to participate regionally in the remodeling process described hereinabove.

The remodeling process contributes to the strengthening of the entire bone, including the new bone formed within the recessed areas. Even after the new bone cells fill the entire recess, the process of bone remodeling may continue through the entire bone contact surface.

It is appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the present invention includes both combinations and subcombinations of various features described hereinabove as well as variations and modifications thereto which would occur to a person of skill in the art upon reading the above description and which are not in the prior art.

CLAIMS

1. An implantable artificial joint prosthesis comprising:

at least one joint defining element defining a bone-engaging surface, said bone-engaging surface including an anchoring mechanism operative for enhancing anchoring and adhesion of the joint defining element to the bone and thus improving the stability and longevity of the prosthesis.

2. An implantable artificial joint prosthesis according to claim 1 and wherein said at least one joint defining element is formed of a material having mechanical properties which are characterized by a non linear stress strain relationship.

3. An implantable artificial joint prosthesis according to claim 1 or claim 2 and wherein said at least one joint defining element defines a generally hemispherical convex bone-engaging surface.

4. An implantable artificial joint prosthesis according to claim 1 or claim 2 and wherein said at least one joint defining element defines a generally hemispherical concave bone-engaging surface.

5. An implantable artificial joint prosthesis according to claim 3 and wherein said at least one bone engagement surface has formed thereon a generally annular outwardly extending protrusion.

6. An implantable artificial joint prosthesis according to claim 4 and wherein said at least one bone engagement surface has formed thereon a generally annular inwardly extending protrusion.

7. An implantable artificial joint prosthesis according to claim 5 or claim 6 and wherein said protrusion defines a generally annular undercut.

8. An implantable artificial joint prosthesis according to any of the preceding claims and wherein said at least one bone-engaging surface is arranged for snap fit engagement with a bone.

9. An implantable artificial joint prosthesis according to any of the preceding claims and wherein said at least one bone-engaging surface is arranged for press fit engagement with a bone.

10. An implantable artificial joint prosthesis according to any of the preceding claims and wherein said at least one bone-engaging surface is configured with a hexagonal configuration pattern.

11. An implantable artificial joint prosthesis according to claim 10 and wherein said hexagonal configuration pattern is defined by a plurality of protruding hexagonal contact surface portions, each surrounded by a peripheral channel.

12. An implantable artificial joint prosthesis according to claim 10 and wherein said hexagonal configuration pattern is defined by a plurality of recessed hexagonal contact surface portions, each surrounded by a peripheral channel.

13. An implantable artificial joint prosthesis according to claim 11 or claim 12 and wherein said channels are each defined by wall surfaces and a bottom surface.

14. An implantable artificial joint prosthesis according to claim 11 or claim 12 and wherein said channels are defined to provide an undercut engagement portion.

15. An implantable artificial joint prosthesis according to claim 13 and wherein said channels are defined to provide an undercut engagement portion.

16. An implantable artificial joint prosthesis according to claim 15 and wherein said undercut engagement portion comprises a relatively wider cross sectional dimension near said bottom surface and a relatively narrower cross sectional dimension

away from said bottom surface.

17. An implantable artificial joint prosthesis according to any of claims 1-9 and wherein said at least one bone-engaging surface is configured with a spiral configuration pattern.

18. An implantable artificial joint prosthesis according to claim 17 and wherein said spiral configuration pattern is defined by spiral recess.

19. An implantable artificial joint prosthesis according to claim 18 and wherein said spiral recess is defined by wall surfaces and a bottom surface.

20. An implantable artificial joint prosthesis according to claim 18 and wherein said spiral recess is defined to provide an undercut engagement portion.

21. An implantable artificial joint prosthesis according to claim 19 and wherein said spiral recess is defined to provide an undercut engagement portion.

22. An implantable artificial joint prosthesis according to claim 21 and wherein said undercut engagement portion comprises a relatively wider cross sectional dimension near said bottom surface and a relatively narrower cross sectional dimension away from said bottom surface.

23. An implantable artificial joint prosthesis according to any of claims 1-9 and wherein said at least one bone-engaging surface is configured with a pattern defined by a plurality of multidirectional generally radially extending elongate recesses.

24. An implantable artificial joint prosthesis according to claim 23 and wherein said recesses are defined by wall surfaces and a bottom surface.

25. An implantable artificial joint prosthesis according to claim 23 and wherein said recesses are defined to provide an undercut engagement portion.

26. An implantable artificial joint prosthesis according to claim 24 and wherein said recesses are defined to provide an undercut engagement portion.

27. An implantable artificial joint prosthesis according to claim 26 and wherein said undercut engagement portion comprises a relatively wider cross sectional dimension near said bottom surface and a relatively narrower cross sectional dimension away from said bottom surface.

28. An implantable artificial joint prosthesis according to any of claims 1-9 and wherein said at least one bone-engaging surface is configured with a geometric configuration pattern.

29. An implantable artificial joint prosthesis according to any of claims 1-9 and wherein said at least one bone-engaging surface is configured with a fractal configuration pattern.

FIG. 1

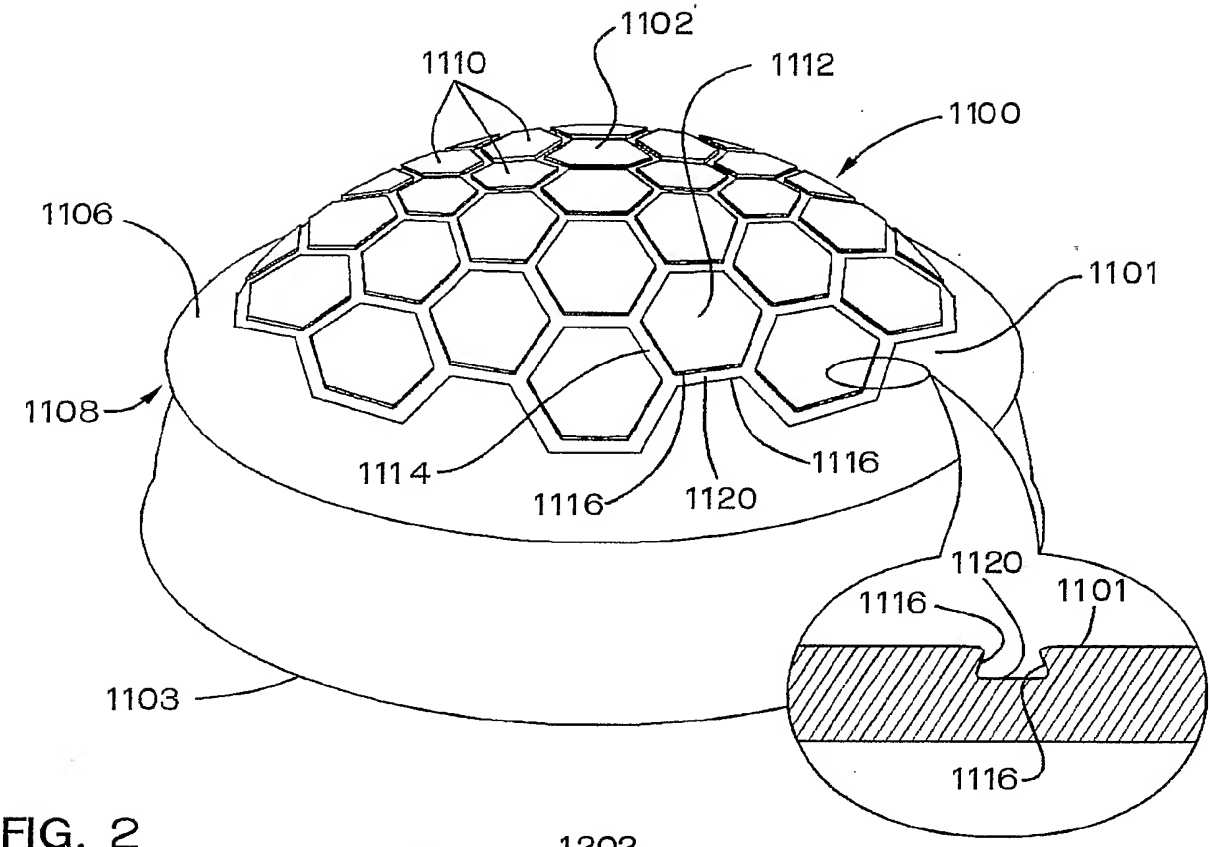
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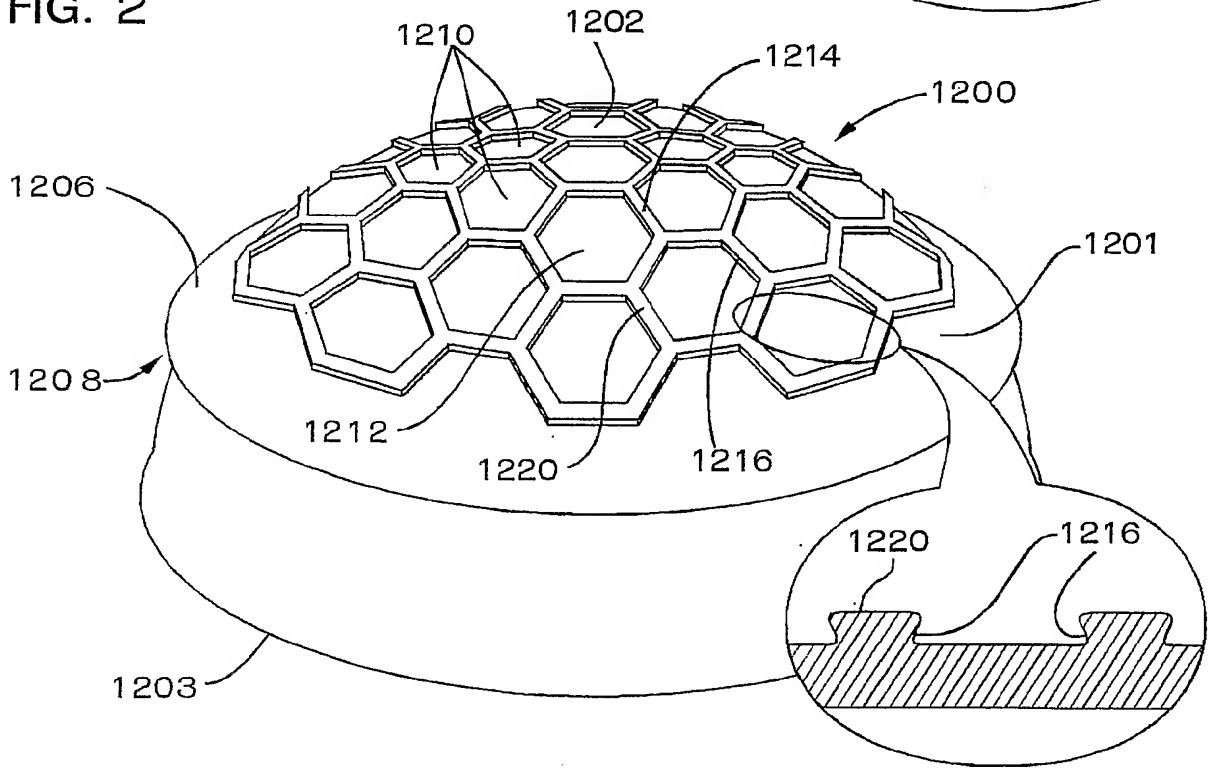
FIG. 2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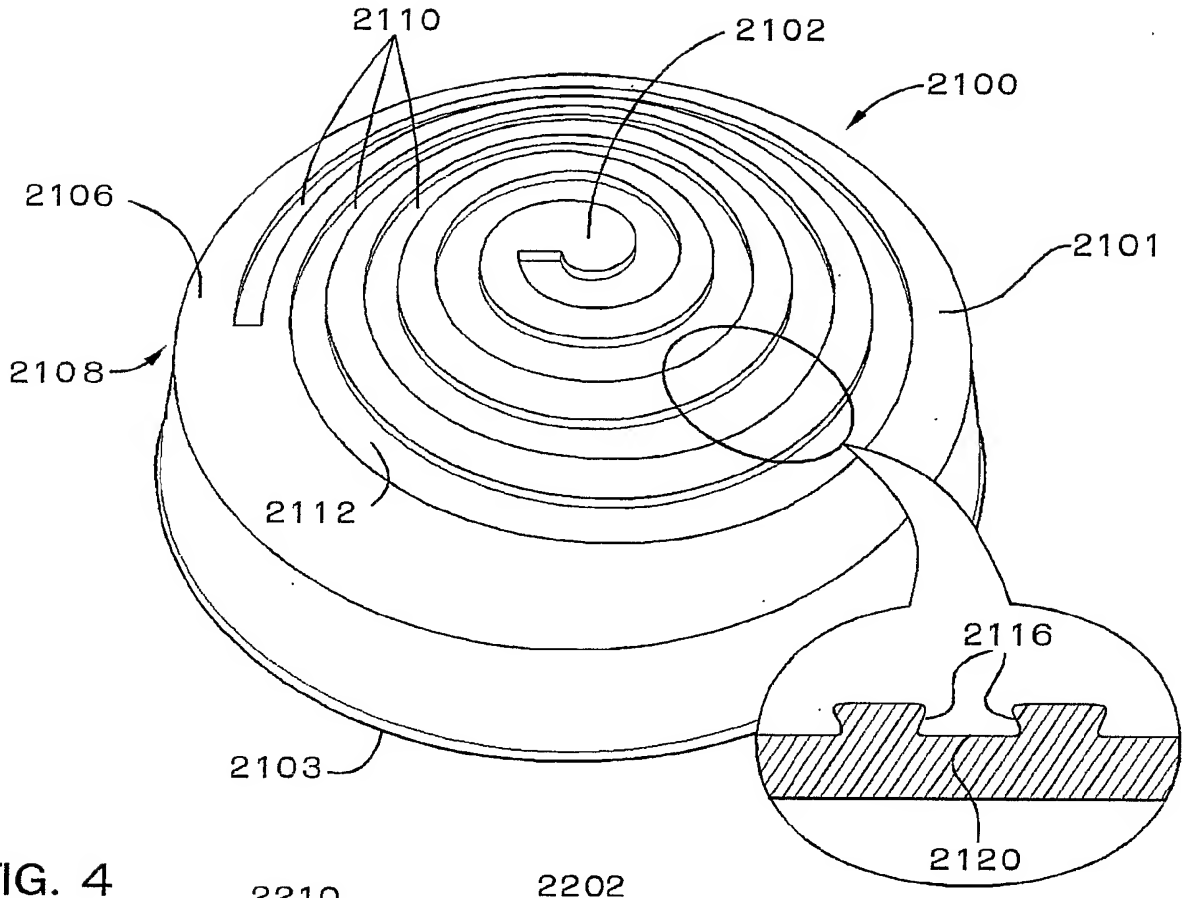
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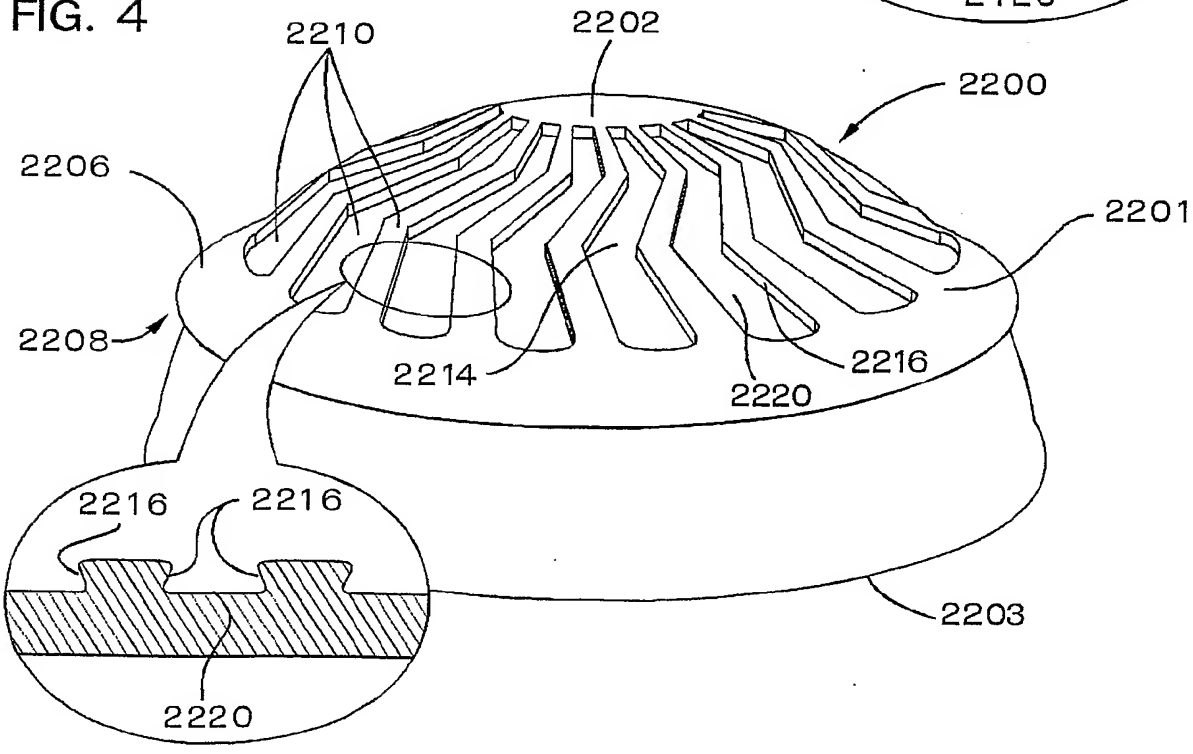
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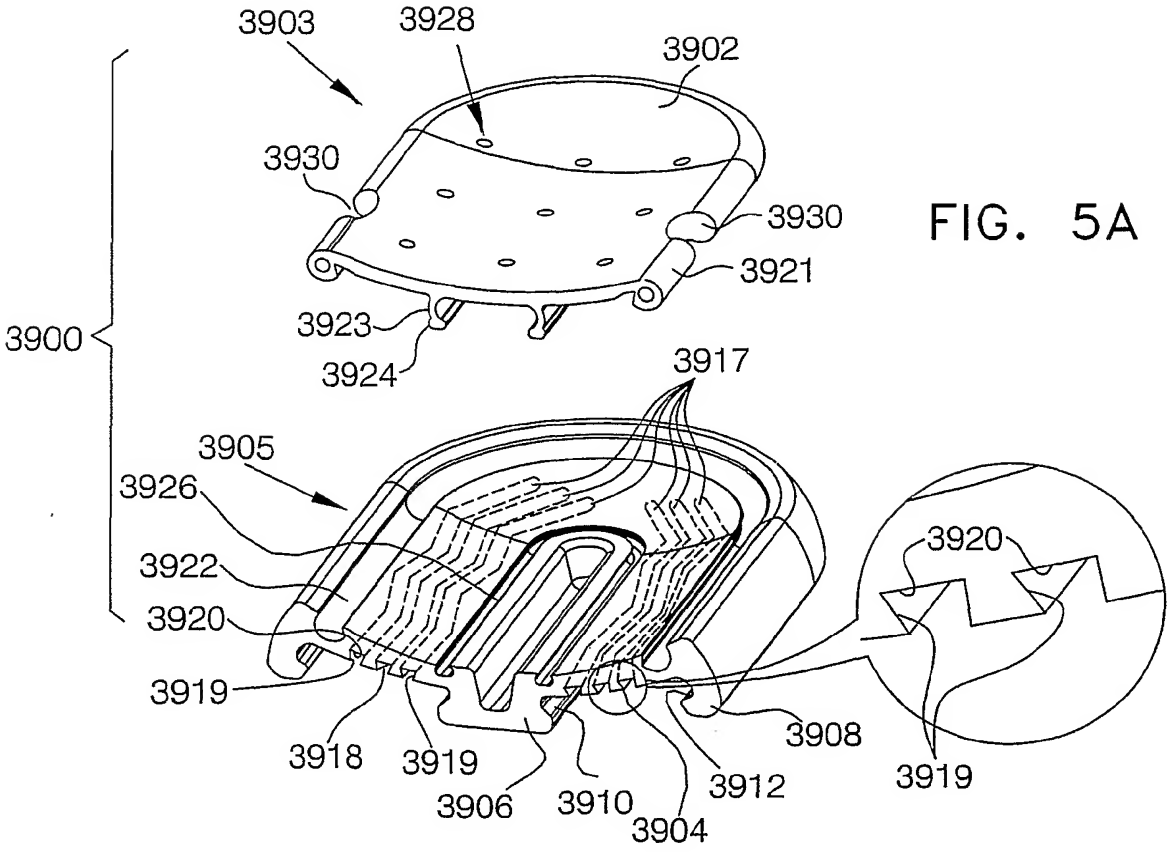
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FIG. 5A

FIG. 5B

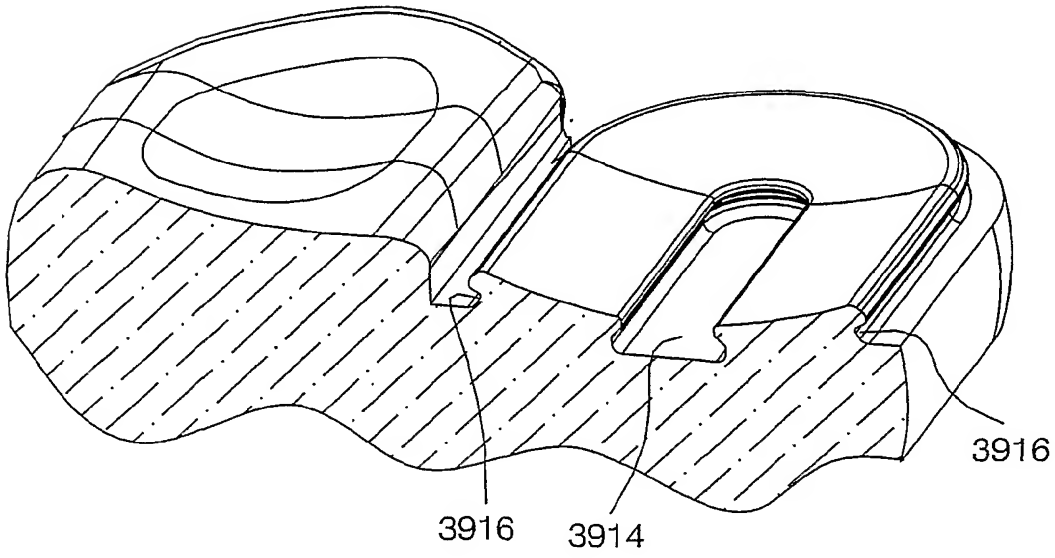
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FIG. 6B

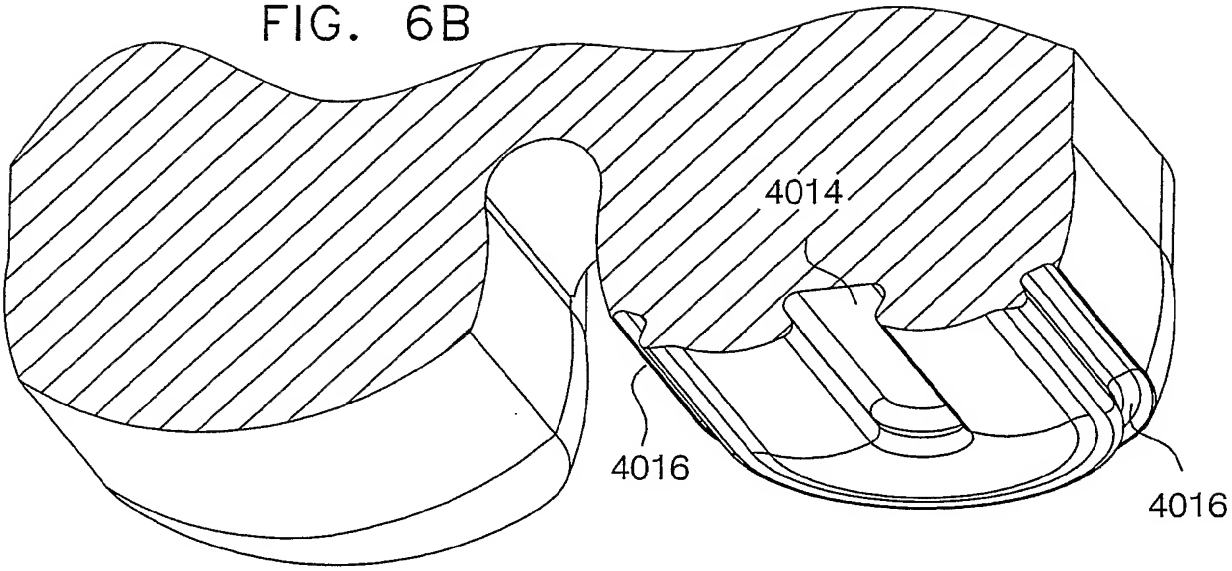
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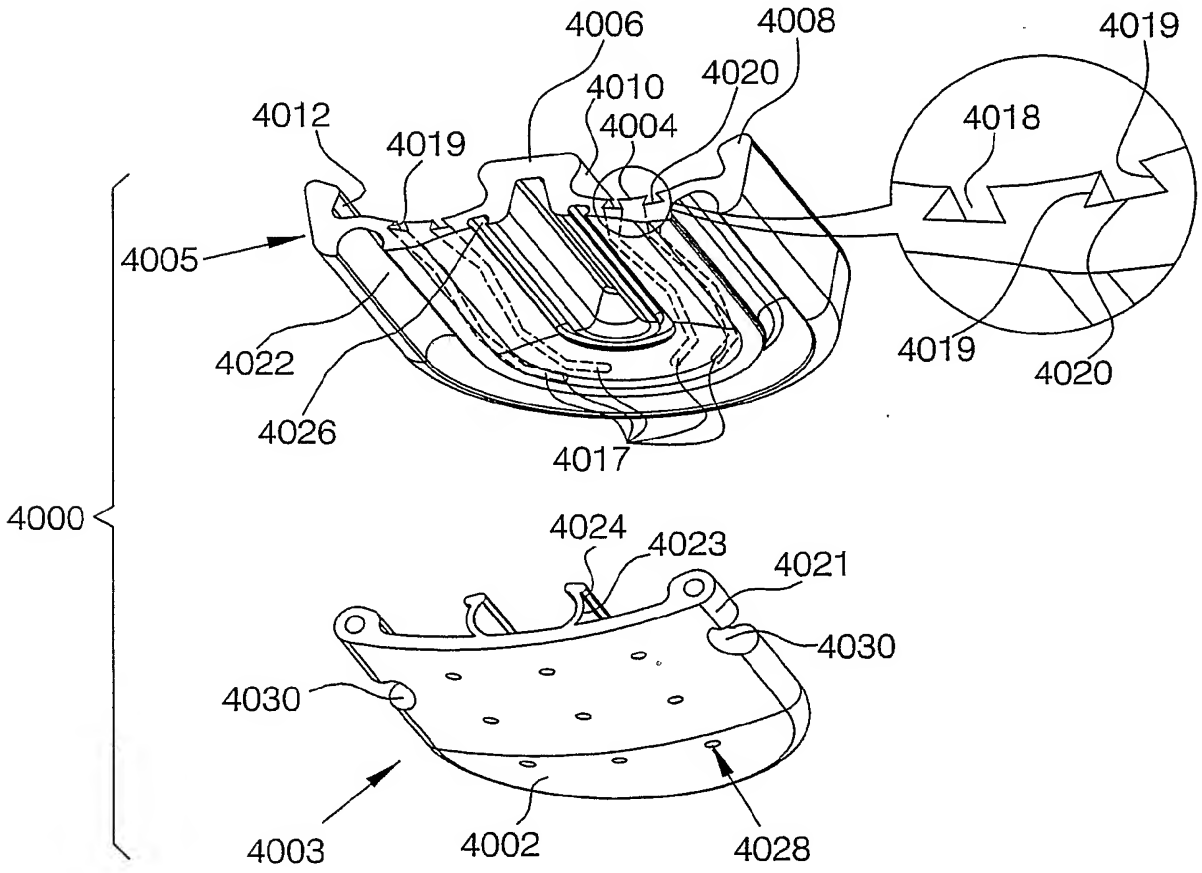
FIG. 6A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